Sounding Rocket Working Group

SRPO Summary

January 20, 2006

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Presentation Outline

- SRPO Personnel Additions
- Mission Results Summary (since last meeting)
- FY06-FY08 Manifest
- Anomaly Investigation Status
- Accomplishments
- Foreign Missions
- Policy Concepts
- Technology Update
- Rocket Motor Status and Vehicle Development
- Findings from June SRWG Meeting

Personnel Additions

- Chuck Brodell
  - Mechanical Engineering Background
  - Significant Sounding Rocket Experience
- Greg Smith
  - Electrical, Safety & Software Background
  - Significant Sounding Rocket Experience

Mission Results Since Last SRWG

- 11 Total Missions
  - 2 Science
    - Korendyke – WSMR (exp. problem)
    - Judge – WSMR (success)
  - 0 Educational
  - 2 Technology
    - Terrier-ASAS Demonstration
    - Sub-TEC ***Sub***orbital ***T***echnology ***E***xperiment ***C***arrier
      - Test platform for new systems
      - Clamp Release requalification
  - 7 Reimbursable
    - Target missions
    - Army Infrasound missions

FY06 Launch Schedule

#	Vehicle Type	FY 2006 Mission	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
		WALLOPS ISLAND												
1	Test Vehicle	HICKMAN/NASA			▲									
2	Terrier Orion	PLAYER/LARC									△			
3	Black Brant IX	EARLE/UNIV. OF TEXAS-DALLAS												△
4	Test Vehicle	HICKMAN/NASA							△					
		WSMR												
5	Test Vehicle	COSTELLO/NASA-NSROC					△							
6	Black Brant IX	RABIN/GSFC				△								
7	Black Brant IX	KANKELBORG/MONTANA ST. UNIV.				△								
8	Test Vehicle	COSTELLO/NASA-NSROC									△			
9	Black Brant IX	MCCANDLISS/JHU						△						
10	Black Brant IX	MCCAMMON/UNIV. OF WISCONSIN							△					
11	Terrier Orion	SEYBOLD/JPL						△						
12	Black Brant IX	CASH/UNIVERSITY OF COLORADO											△	
13	Black Brant IX	HASSLER/SWRI									△			
14	Black Brant IX	MOSES/NRL										△		
15	Black Brant IX	CRUDDACE/NRL												△
		NORWAY												
16	Terrier Orion	WHEELER/PENN STATE UNIVERSITY									△			
		REIMBURSABLE MISSIONS												
17	Terrier Oriole	WINSTEAD/NAWC (HAWAII)		▲										
18	Orion	WINSTEAD/NAWC (WSMR)		▲										
19	Terrier Orion	WINSTEAD/NAWC (WSMR)		▲										
20	Terrier Orion	WINSTEAD/NAWC (WSMR)		▲										
21	Orion	WINSTEAD/NAWC (WSMR)						△						
22	Orion	WINSTEAD/NAWC (WSMR)						△						
23	Orion	WINSTEAD/NAWC (WSMR)	TBD											
24	Orion	WINSTEAD/NAWC (WSMR)	TBD											
25	Orion	WINSTEAD/NAWC (WSMR)	TBD											
26	Orion	WINSTEAD/NAWC (WSMR)	TBD											

FY07 Manifest

	Mission	Launch Date	Site	PI	Comments
1	36.233	Oct	WSMR	Woods	
2	36.XXX	Oct	WSMR	Judge	Refly of 36.227 – MIC needed
3	36.225	Jan	WSMR	Chakrabarti	Planet Imaging – Unique ACS requirement
4	35.038	Jan	PFRR	Lessard	Rocket assisted ejectable sub-payloads
5	21.138	Jan	PFRR	Larsen	JOULE 2
6	36.234	Jan	PFRR	Larsen	JOULE 2
7	41.064	Jan	PFRR	Larsen	JOULE 2
8	41.065	Jan	PFRR	Larsen	JOULE 2
9	35.037	Feb	PFRR	Craven	Tailored Trajectory
10	41.061	Feb	PFRR	Craven	TMA
11	41.062	Feb	PFRR	Craven	TMA
12	41.063	Feb	PFRR	Craven	TMA
13	40.019	Feb	PFRR	LaBelle	CHARM
14	36.226	May	WSMR	Bock	
15	41.XXX	May	WFF	Hickman	Technology
16	41.069	June	Andoya	Robertson	Notcilucent Cloud
17	41.070	June	Andoya	Robertson	Noctilucent Cloud
18	36.213	June	WSMR	Porter	New SPARCS Payload

FY08 Manifest

	Mission	Launch Date	Site	PI	Comments
1	36.173	Nov	WSMR	Norseick	
2	35.036	Dec	Andoya	Kletzing	Big launcher needed
3	40.018	Dec	Andoya	Kletzing	Big launcher needed
4	Brant				
5	Brant				
6	Brant				
7	Brant				
8	Surplus				
9	Surplus				
10	Surplus				
11	Surplus				
12	Surplus				
13	Surplus				
14	Surplus				
15	Surplus				
16					

Active Mishap Investigation Boards (MIB)

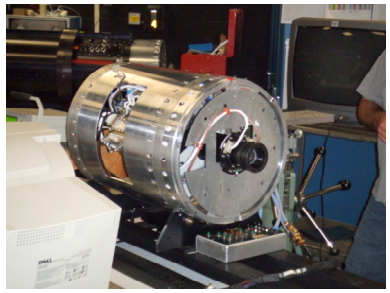
Failure	AIB lead	Status
BBXII Vehicle Failure – 40.017 (Poker 2005)	NASA (Nelson)	Draft HQ Endorsement letter obtained
36.222 DS Experiment Failure	NRL	Closed - Problem traced to dislodged circuit board

SRPO Mission Schedule

- Known as the “Blue Book”
- Now available on-line
- E-mail indicating where to find the PDF file will be issued on monthly basis
  - While the site is “open to the public” there will be no link from the SRPO or NSROC web sites
  - SRWG members that did not receive an e-mail in early January should leave their e-mail address with SRPO staff before departing…

Accomplishments

- Celestial ACS
  - Air bearing tests completed
  - Test flight scheduled for Feb 9, 2006
    - NSROC will provide details during PM session
- Terrier-ASAS
  - Demonstration mission launched on 6/28/05
  - 21” diameter motor with Brant class performance
  - Also tested ATK guidance system
    - To be used on ATK X1 launch vehicle

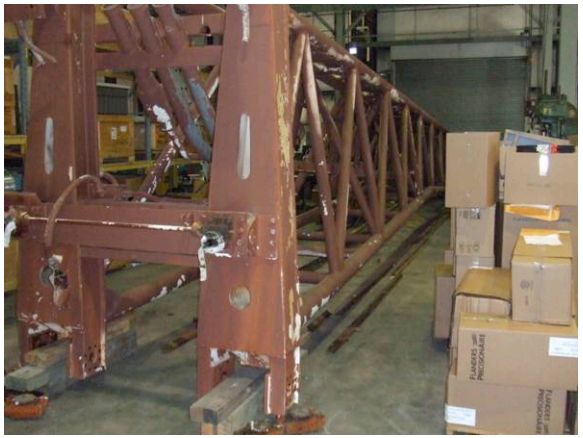


Accomplishments

- SubTEC Mission Launched
  - Reusable, standardized technology demonstration payload
  - Recovered 100 nmi off shore
    - Longest to date
    - Rough seas
  - Template for possible scientist and engineer "training rocket"
  - Reusable standardized systems will help flight demonstrate new systems at reasonable cost
  - Several NSROC sub-systems flight tested on this mission
    - Worked well and will be reported by NSROC

Accomplishments

- 50K Launcher
  - To be installed at Andoya
    - Will support Kletzing mission
  - On long-term loan from Naval Air Weapons Center (Winstead)
  - Hardware assessment completed
  - Andoya launcher shelter modifications incorporated into design.
    - Delta cost to be covered by SRPO (minimal)
    - Shelter fabrication underway



Upcoming Foreign Missions

- Norway (Wheeler)
  - June 2006 Launch
  - Cooperative educational mission
  - NSRP providing only the Terrier-Orion launch vehicle
  - Payload Funded by Penn State and Corporate sponsors
  - Range costs being covered by Andoya Rocket Range
- Norway (Robertson)
  - June/July 2007
  - Collaborative mission with ARR and German/Norwegian ECOMA rocket campaign
  - Under-flight for AIM satellite
- Norway (Kletzing)
  - Slipped to Dec 2007 (FY08)
  - Norwegian mission from Svalbard scheduled for same period
    - ARR says personnel should not be an issue
    - NASA launcher needed to resolve conflict

Policy Concepts

- New Payload Integration
  - SRPO proposes that all new payloads (with exception of solar missions) be integrated at Wallops
  - Rationale
    - Experience indicates that more problems exist with new payloads
    - NSROC has traveled to the field on several occasions only to spend weeks trouble shooting problems before returning home
    - More resources available at WFF
    - Doesn't tie up NSROC personnel in the field
    - Potential to minimize NSROC travel costs
    - Can help reduce risk

Policy Concepts

- Payload Vibration
  - Waivers to undergo increased scrutiny
  - Vibration research being conducted
    - Flight data being collected
    - Vibration specifications may be redefined
    - Waivers will be much more difficult to justify once new specs are defined

Policy Concepts

- Test Flights
  - "One-time" missions should not serve as test flights…

  However,

  - In some situations, does it make sense to attempt to get science in parallel with a subsystem test?
    - Should we burn a critical asset (Brant motor) with no prospect of getting science data
    - If the payload is recoverable, do we lose anything?
      - Obviously once in a lifetime events wouldn't be considered
        - » Unless that once in a lifetime event would be missed…
    - If the test article doesn't perform properly, the science mission may be delayed anyway…
    - Examples: Upgraded S-19, new upper stage ignition system, new ACS, etc.

Technology Development

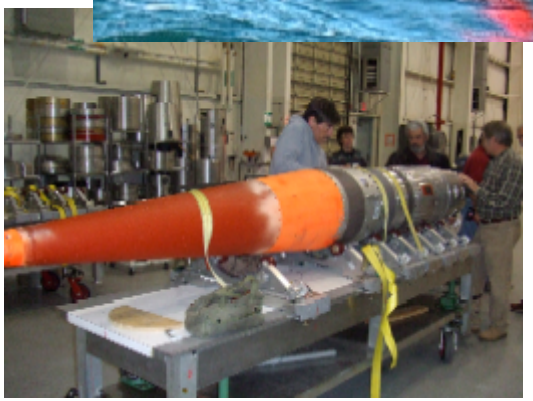
Technology Update

- 2nd biggest hurdle in developing a robust Technology Program for the SRPO has finally been overcome
  - The addition of staff – Greg and Chuck
  - Two experienced engineers encompassing many functional areas
    - Electrical, mechanical, software, operations, T&E, safety
    - Both have previously worked in sounding rockets
- The biggest hurdle……funding……we are doing what we can
- Over next several months we will develop a technology roadmap
  - Incorporate short term program enhancements
  - Long term vision based on SRWG inputs and budget realities
- Short term strategy is being implemented now
  - Using available staff and resources to pick the low hanging fruit
  - We have made some significant strides

Technology Update

Sub-TEC - ***Sub***orbital ***T***echnology ***E***xperiment ***C***arrier

- Reusable water recovered payload
  - Used to test new systems and technologies
  - Could be flown again < 2 months
- Strategic use of scarce resources
  - Re-qualification of Terrier Clamp Release system
  - Primary carrier built using in-house systems, available hardware, and labor
  - Partially funded by KSC/WFF piggy back experiment
    - STARS – Space-based Telemetry and Range Safety
    - Could have future potential SR applications
  - NSROC flew several new SR sub-systems – all successful
- 100 nm recovery - a first for WFF
- Kudos to NSROC team for innovations and schedule
  - New ways to seal compartments
  - Maximized reuse of hardware
  - Concept to launch in ~7 months

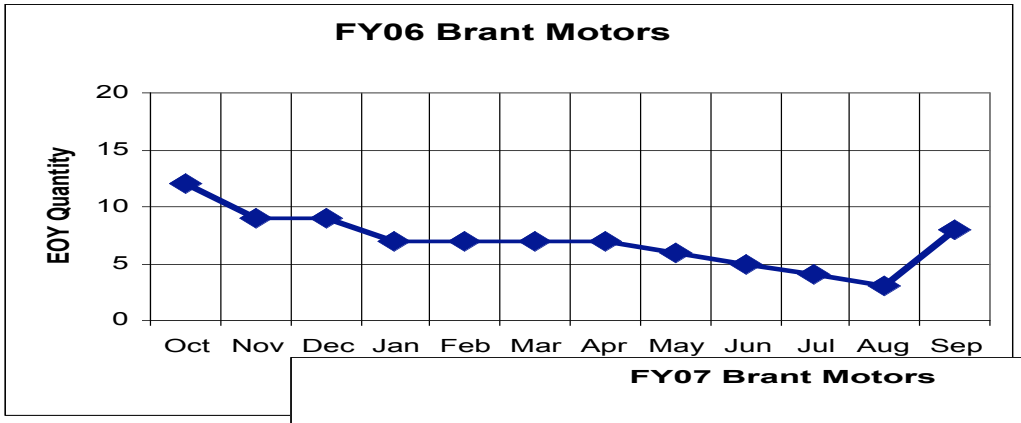


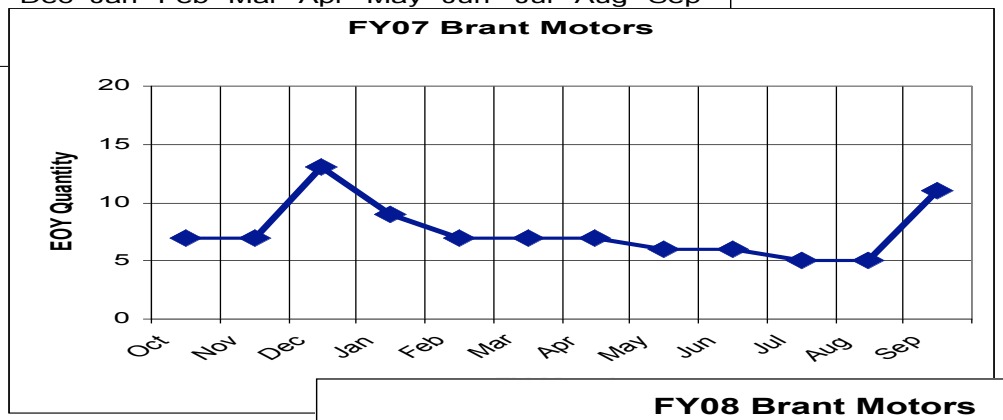
Technology Update

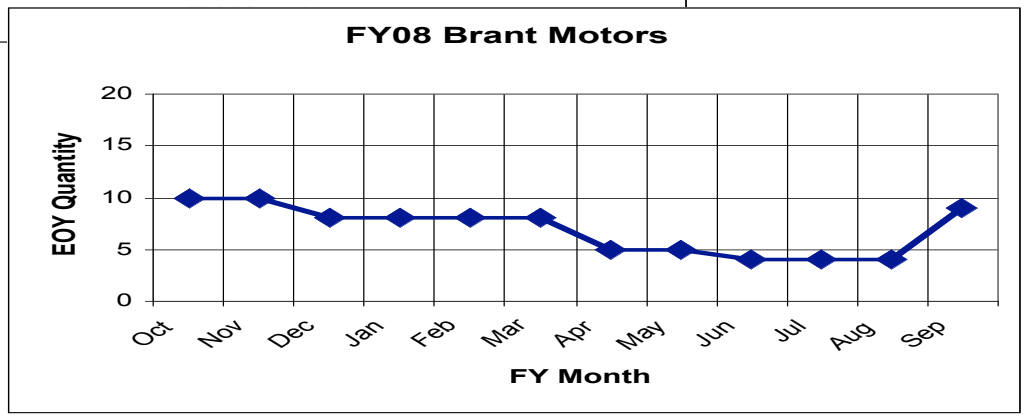
- Projects currently in work
  - Orion fin optimization
    - Increase stability and performance
    - Hybrid team of NASA AETD and NSROC personnel
  - MRLS development
    - Team being formed – lead by new Technical Manager
    - Will include multiple vehicle only and payload development flights
    - Will likely be a hybrid team
- Focus for this coming year
  - New vehicle developments
    - Terrier Patriot – analysis and perhaps test flight in late CY 06
    - Taurus replacement in BBXI and BBXII – 40+ year old motors
    - Talos-ASAS 28 – may be done with DoD project funds
    - ATACMS - potential Brant class surplus @ 24” diameter
  - Recovery systems
    - Phone home location system
    - Parachute water release
    - Floatation augmentation
  - NSROC in-house system developments – reported later by NSROC

Rocket Motors Status

Brant Motor Inventory Projection



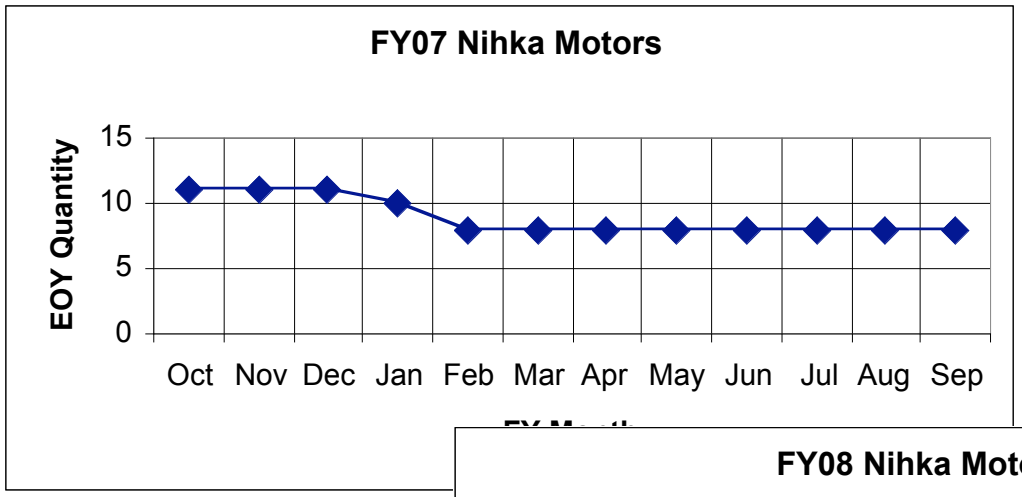


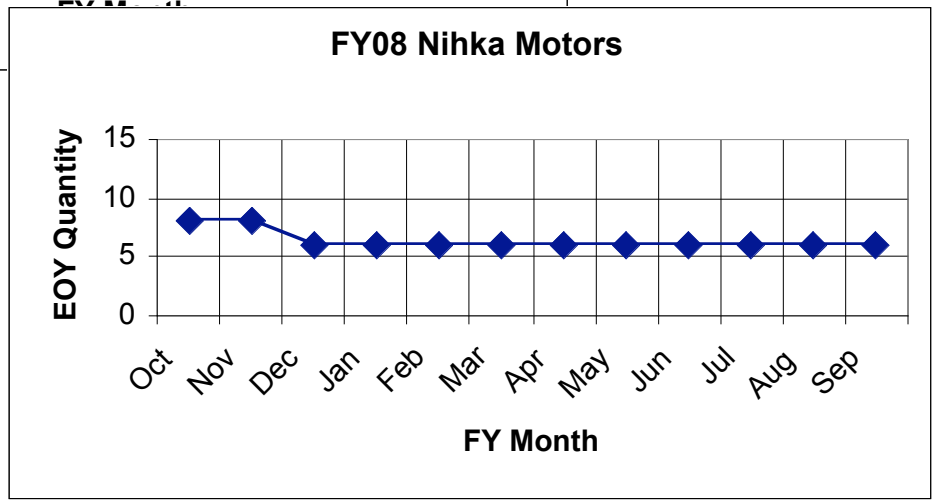


Brant Status

- Ignitability tests compete
  - Mk1 propellant ignites a little more readily than old Aeroplex propellant
- Igniter test cell being tested and calibrated
  - Test igniters fired to calibrate heat flux sensors
- Procurements for long lead-time items initiated months ago
  - Casings, fins, nozzles, exit cones etc.
- Funding has been authorized to begin propellant casting on 6 first six motors
  - Casting to begin before the test flight

Nihka Motor Inventory Projection





Nihka Situation

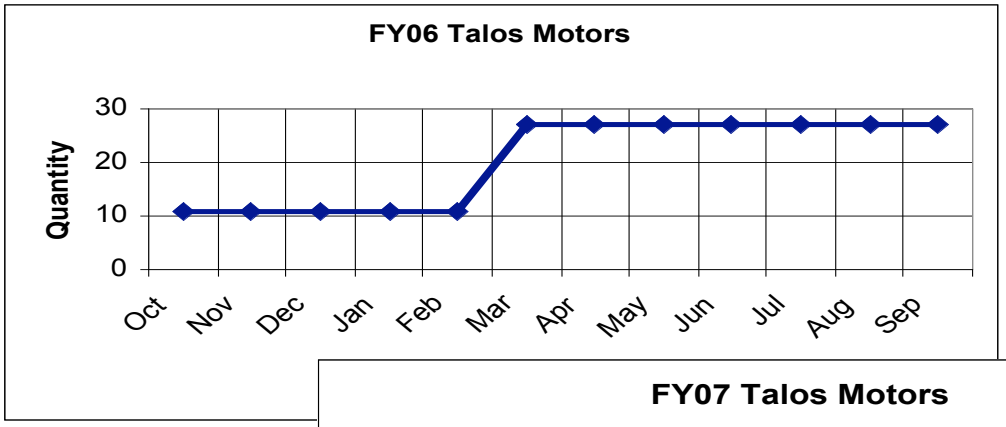
- Inventory situation is critical
- $500K to $1M needed to develop new design
- SRPO is working a deal to acquire 3 Nihka motors from NASIC
  - Older version which must be flown with heavier payload (>500 pounds)

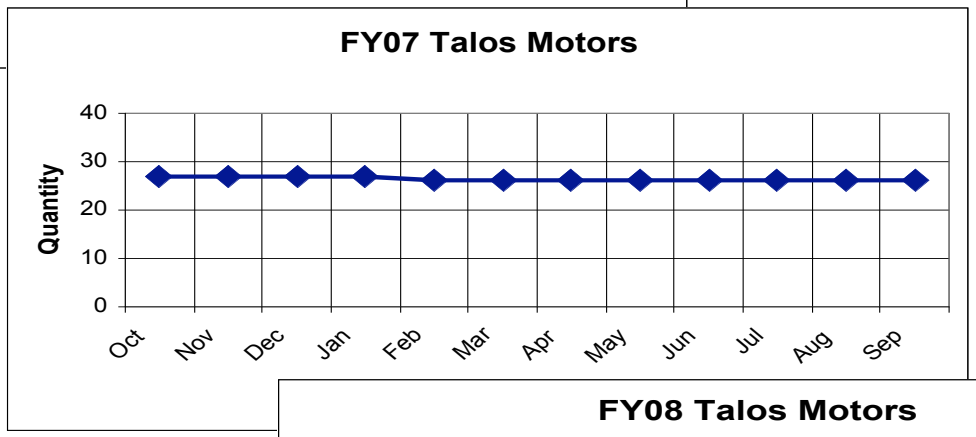
Nihka Plan

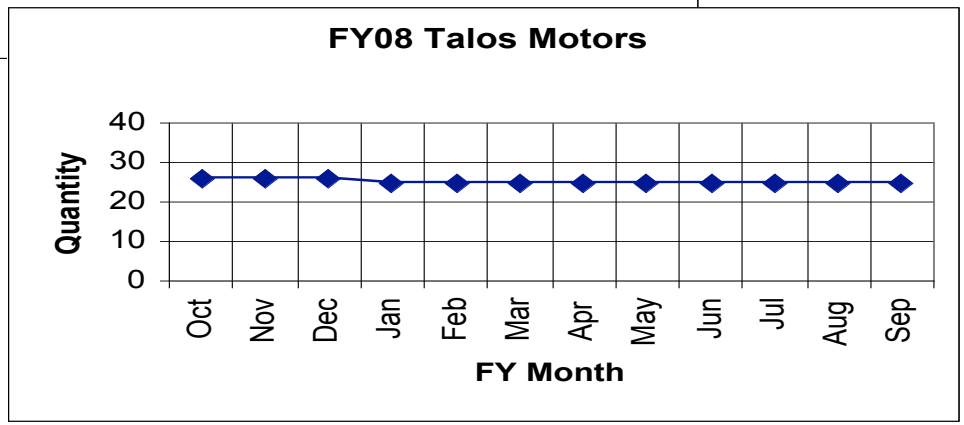
- Existing motor configurations/combinations are not capable of providing comparable performance
- SRPO will investigate alternative vehicle stack combinations utilizing surplus/procured combinations
  - Will conduct cost/performance trade-off analysis to determine most efficient solution

- Procurement of Nihka replacement initiated
  - Draft Request for Information (RFI) complete and in final review to be released February 2006
    - RFI to be submitted to Commerce Business Daily (CBD) and existing motor providers
  - Planned Request for Proposal (RFP) release in June 2006
  - Contract award expected in December 2006 with first delivery in January 2008

Talos Motor Inventory Projection







"New" Rocket Motor Status

The SRPO continues to investigate the use of surplus motors to expand program capabilities. Two motor systems are showing promise:

- Patriot (surplus)
  - Terrier-Patriot could replace portion of single stage Brant vehicles
  - Have requested 50 units from Army
  - Feedback from DoD contact increasingly positive
- MLRS (surplus)
  - Tentatively called the "Mesquito"
  - Will provide 4.0-inch dia. dart payload
  - MLRS Motors in-hand
  - Climate has improved
    - Funding situation has stabilized
    - New Technology Managers now available to help development move forward

SRWG Findings from June 16, 2005 Meeting

I. Annual Poker Operations

- White Paper submitted to HQ for consideration
  - Conclusions
    - No or very little cost impact on program
      - Only one planned moon down period per year
      - Slips must be managed properly
    - Can accommodate 4-5 rockets per year
    - Should help level the NSROC workload
      - Science teams need to do there part in keeping missions on track
- New Poker contract is being negotiated w/ annual operations in mind

II. Financial Concerns and Resulting Delays

- Goddard full cost rates
  - Seem to have stabilized
  - Quite “low” relative to other Centers
- SRPO continues to work to minimize erosion of funding
- SRPO is actively tapping into non-NASA funding sources to move new developments forward

III. Black Brant Motors & Alternate Vehicles

- Black Brant Motor Recovery
  - Proceeding well…….a little longer than desired but technically things are progressing
  - Good ignitability data gained in late December
  - Fixing the igniter should be relatively strait forward
  - Will be briefed in more detail as part of AIB and Recovery Plan presentation
  - Order for Brant motors is being placed now
    - Minimize the risk of startup problems with Bristol casting line
    - Minimal technical and financial risk to SRPO

III. Black Brant Motors & Alternate Vehicles

- Alternate Brant Vehicles
  - **Terrier-ASAS**
    - Test flight conducted in June and proved to be feasible alternative
      - New fin design needed to optimize performance and stability
  - **Terrier-Oriole**
    - Flown 4 times successfully – 1 NASA; 3 Navy
      - New fin design needed to optimize performance and stability
  - Neither the ASAS nor the Oriole are currently in production
  - Anticipate 12-18 months for first delivery once order is placed
  - Still almost twice as expensive as a Black Brant
  - **Surplus ATACMS** (Army Tactical Missile System) boosters were recently made available surplus
    - 24” diameter Brant class motor
  - **Terrier Patriot**
    - Process to obtain 10 motors has been initiated
    - Terrier Patriot (16 in diameter) = single stage Brant

IV. Low Cost Mesospheric Rocket Development

- What is new
  - Decision to move forward for development of mesospheric sounder has been made
  - Detailed formulation effort is next major hurdle
    - Define user requirements in detail
    - Formulation will look at all options to meet requirement
    - Define cost, technical, and safety issues
    - SRWG input is vital to this effort – we still need it!!
      - Altitudes, how many, how often, sensor exposure, max loads, coning, attitude knowledge, etc.
      - All will factor into our decision on how to proceed
  - Project team formation underway
    - Will be lead by SRPO Technical Manager
    - Most likely a hybrid team – NASA/NSROC
  - Top level risks and issues defined for MLRS
  - Top level approach to mitigate risk defined

IV. Low Cost Mesospheric Rocket Development

- MLRS Issues and Risks
  - Known issues with this system and this type of system are driving design envelope
  - Limits the weight, volume, and location of experiments
  - Concerns of the SRWG and will be taken into account
  - Primary concern is to avoid problems associated with Super Loki/Viper while keeping cost to acceptable levels

➢Vehicle Risks

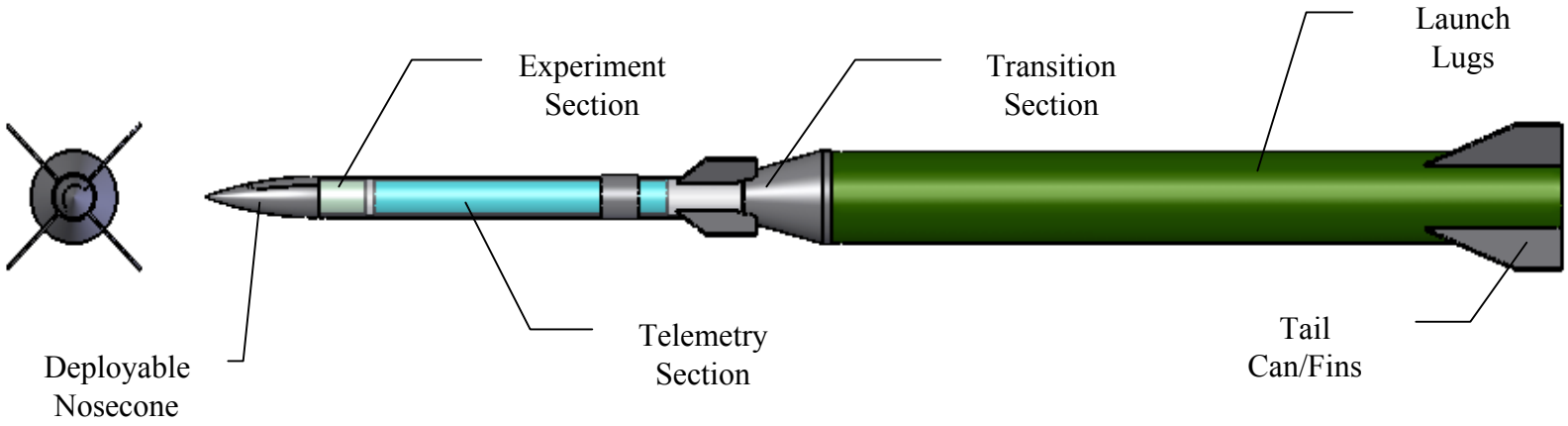
- **➢Rail Lugs**
- **➢Fins**
- **➢MLRS to Dart Transition**
- **➢Deployable Nosecone**
- **➢Motor Inspection Process**
- **➢High QE Launch Performance**

➢Payload Risks/Issues

- **➢Weight and CG location**
- **➢Heating**
- **➢Packaging Electronics**
- **➢GPS Acquisition and Lock**
- **➢Ground Systems Tracking Ability**
- **➢Adequate Space for Scientific Instruments**

IV. Low Cost Mesospheric Rocket Development

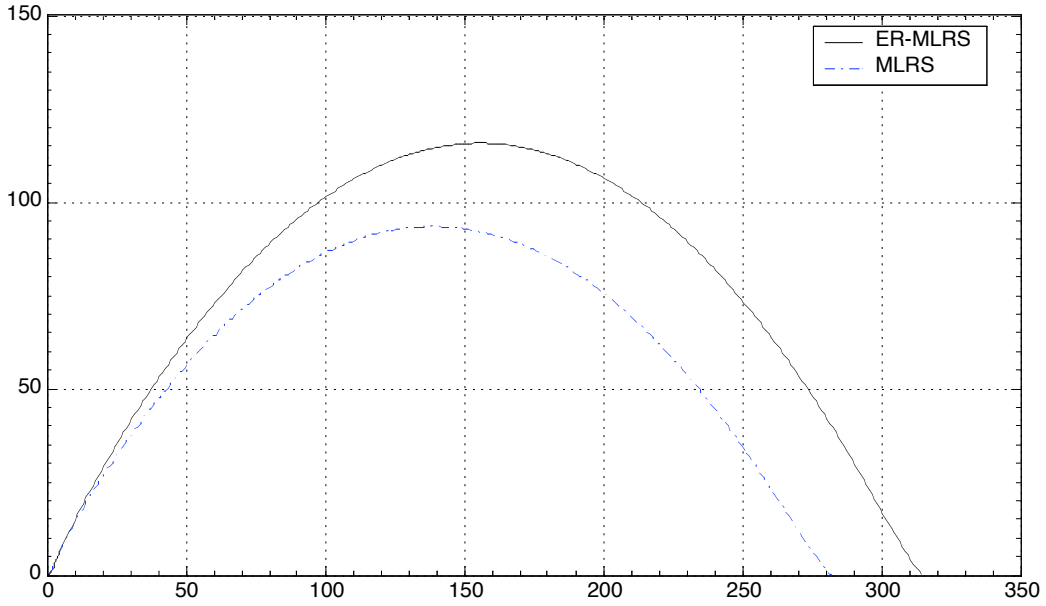
- MLRS Current configuration



IV. Low Cost Mesospheric Rocket Development

- MLRS Projected Performance

115 g's at 1.8 seconds!



Note: Jerk 84 g's 0.0-0.1 sec

IV. Low Cost Mesospheric Rocket Development

- MLRS Development Plan Concept
- Due to known issues & concerns w/ environment several test launches will be conducted to evaluate system(s) performance before we begin flying science missions
- Build and launch 3 “inert” payloads for vehicle
  - Verification of fins and launcher interfaces
  - Dispersion and flight safety operations
- Build and launch 3 test active payloads
  - Verify electronics survivability
  - Heating characterization
  - Range tracking verification

V. Kwajalein as a New "Standard" Range

- BIG QUESTION - How can this be done current financial constraints??
- "Typical" PRD submitted to RTS April 2005
  - Baseline 7 nights 4 hr/window, 1-3 launch salvos, similar to EQUIS II
  - Cost estimate received day before last SRWG meeting
- Good news
  - Cost per mission for launch operations is very attractive
    - ~$130K for 3 launch salvo (~$100K for single launch)
  - RTS is willing to work with us to increase capability – cost sharing has been discussed recently
    - Will require some leg work and negotiations
  - We can implement new concept of operations to reduce cost
  - Expanded trajectory options have been advertised by at RTS
  - Still have time to draw on past experience – keep cost under control
- Not so good news
  - We are still their only sounding rocket customer
  - Set-up cost estimate was higher than anticipated
    - ~$690K based on EQUIS II "campaign" experience
    - We can reduce this cost by taking less equipment

V. Kwajalein as a New "Standard" Range

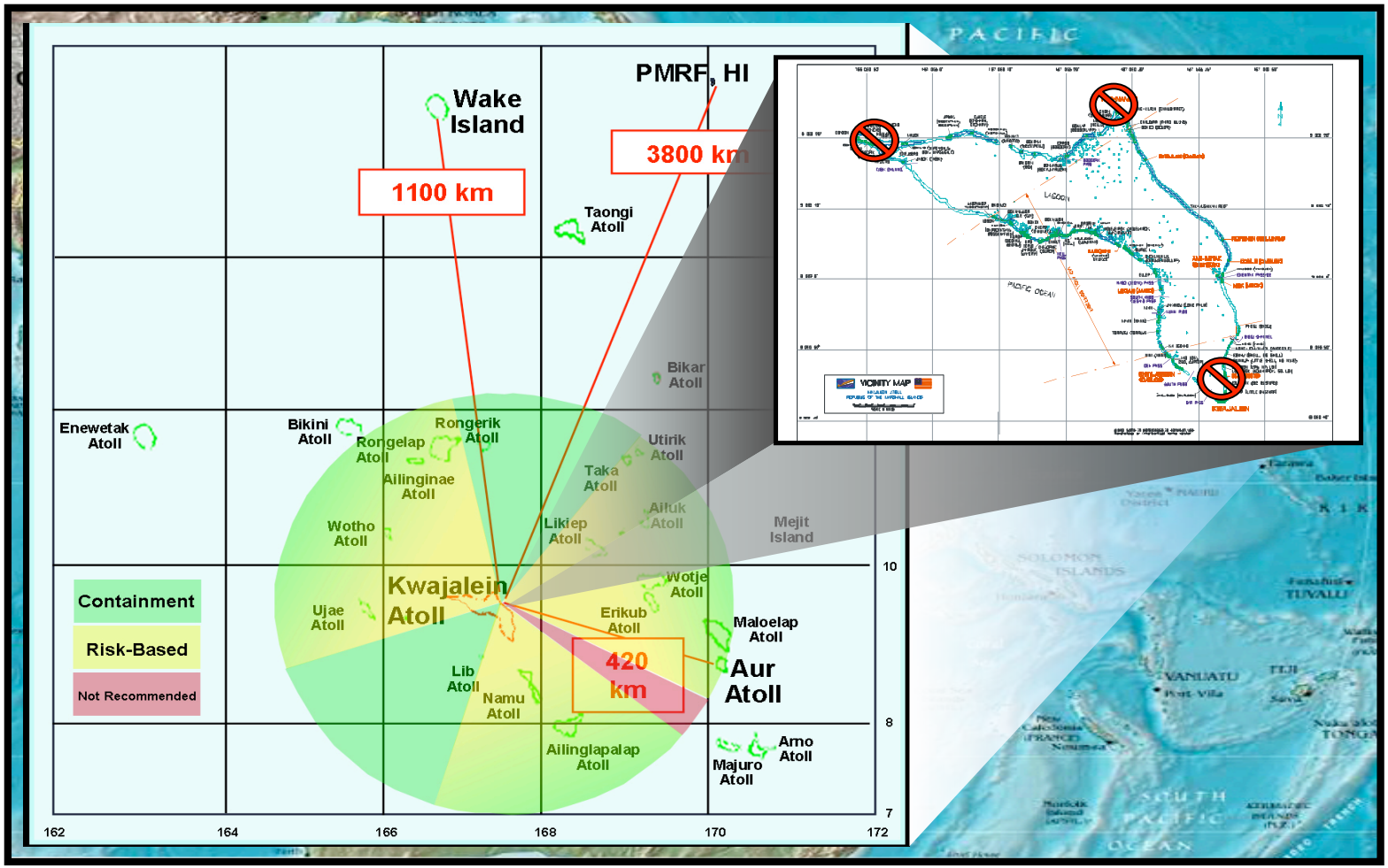
- New Operations Concepts
  - Use lessons learned in EQUIS II & new technologies to reduce cost
- Range infrastructure
  - Eliminate WFF mobile radar
    - Metric tracking can be done with RTS assets – proven
    - Wind weighting done via GPS sondes – almost ready at WFF
  - Eliminate WFF mobile TM Van
    - Tracking, recording, and decom via RTS assets - proven
    - Augment decom/display with WFF rack mount TM equipment
  - Launchers
    - "Permanently" mount 20K launcher vs. taking "MRL" launchers
    - One time investment of ~$160K could save ~$110K for successive missions
    - 20K is good weather resistant launcher that is available and could remain at RTS
  - Facilities
    - Make due with what they have - no net increase
    - Upgrade facilities would cost the program additional
      - Most likely factored into RTS cost estimate recently provided

V. Kwajalein as a New "Standard" Range

- New Operations Concepts Con't
- Payload shipment options
  - Plan to ship payloads via surface vs. air freight
    - Would require us to be ready ~6 weeks prior to typical ship date
  - To ship similar EQUIS II payloads via surface would reduce cost by ~$160K
- Minimize testing with range to keep cost down
  - Portable TM ground stations can be used
- Other considerations
  - Ground based instrumentation in place
    - ALTAIR is paid for/maintained by others
    - Wave form modifications for ALTAIR done - ~$100K
    - AFRL Ionosonde is in place and operating

V. Kwajalein as a New "Standard" Range

- Expanded trajectory options presented at last SRWG



V. Kwajalein as a New "Standard" Range

- Feasibility
  - Appears it is feasible to conduct missions within current cost constraints
  - More data and leg work required to establish firm cost
  - Taking advantage of lesson learned on EQUIS II will reduce cost
  - Spread funding burden over a few years will minimize cost spikes
- AFRL has shown interest in working with SRPO in conjunction with C-NOFS
  - Dr. Donald E. Hunton, Chief Space Weather Effects Section
    AFRL has contacted program office concerning collaboration
  - Perhaps a partner to help fund next mission – ALTAIR for sure
- Summary
  - New program capability is a big incentive
  - Cost per mission is attractive
    - $100K single launch to $130K for 3 launch salvo – 7 day/4 hours each
    - Comparable or better than other established ranges
  - Modest investment to establish second launcher
    - More permanent capability
    - Can be done early to avoid cost spike
  - Work with existing range personnel with experience to keep cost down
  - Make due with facilities used for EQUIS II to keep cost down
  - Appears feasible and in line with other "foreign" missions

VI. NSROC Staffing

- The SRPO budget situation has stabilized
- The current NSROC workforce can be maintained
- Annual mission set must be scaled to available personnel
  - Must minimize overtime
  - Current workforce can support approx 15 flights/yr
- Striving to fill critical technical areas
  - Propulsion Engineer
  - Dynamists